THE RABBIT LEFT VENTRICLE MODELING AT THE CELLULAR SCALE: APPLICATION TO FLOW-CLAMP EXPERIMENTS

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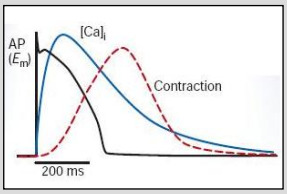
Abstract

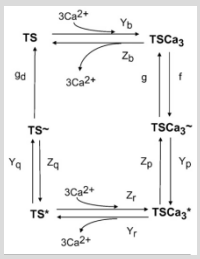
Modeling cardiac function is often considered using a phenomenological approach, where the cardiac contraction is described macroscopically (at the organ level). However, in this study we use a microscopic approach and describe the rabbit ventricular contraction at the cellular and subcellular levels. This leads to a better description of the ventricle contraction during flow-clamp protocols.

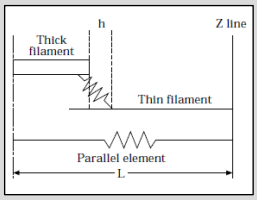
Methods & Results

The model

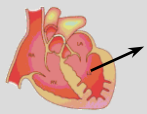
Rabbit ventricular cell model → (Microscopic variables) → Sarcomere length L and generated force F → (Macroscopic variables) → Ventricular volume V and pressure P of the left ventricle







F, L



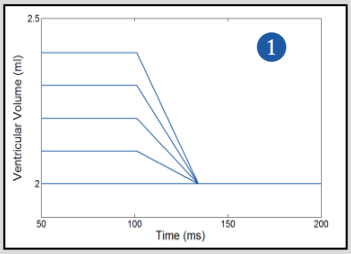
P, V

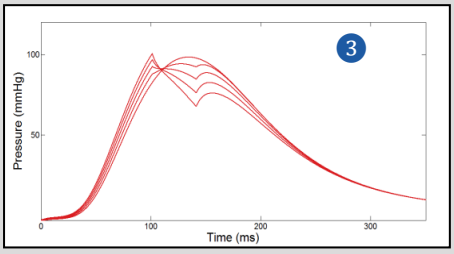
$$V = K_v \cdot (L + L_s)^3 - f \cdot V_w$$

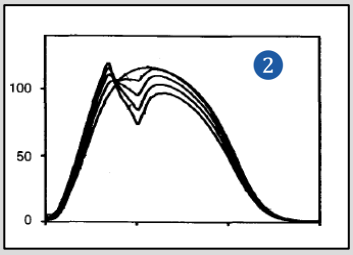
$$P = 5 \cdot \frac{V_W}{K_v \cdot L_r \cdot (L + L_s)^2} \cdot F + \gamma \cdot (V - V_0)^3$$

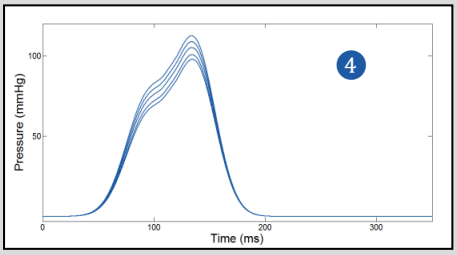
Flow-clamp protocols

Sharp drops in ventricular volume are applied to the excised heart and the ventricular pressure is measured.









1. Five flow-clamps are simulated with flow equal to 0, 3, 6, 9 and 12 ml/s. Flow duration is 33 ms.
2. Experimental results from rabbit left ventricle.
3. Simulation results from our model, based on the cellular scale.
4. Simulation results from the varying elastance model. This empirical and commonly used model is not based on a cellular description and assumes a pressure-volume relationship given by :

$$P = E \cdot V$$

where E is the time varying elastance.

Conclusions

Our rabbit left ventricle model, based on the cellular scale, is able to reproduce properties of the cardiac muscle that cannot be observed with the varying elastance model. This suggests that working with phenomenological models can lead to misinterpretation when studying the cardiac function. Thus, it is preferable to use a cellular model of the heart when developing cardiovascular system models.

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